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EPA in the Lipids of Redfish

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EPA in the lipids of read fish

Hideo TSUYUKI*

1. The effectivenss of EPA

Edible oils and fats consist of numerous types of fatty acids numbering in the several dozens. Among these, linolic acid ($C_{18:2}$ acid), linolenic acid ($C_{18:3}$ acid), arachidonic acid ($C_{20:4}$ acid) are known to be essential fatty acids indispensable to nutrition.

The composition ratio of these essential fatty acids vs. the total fatty acids is higher in liquid vegetable oils than in the lipids of fish. However, the lipids of fish contain highly unsaturated fatty acids not found in vegetable oils or in the fat of land animals, viz. eicosapentaenoic acid (EPA, $C_{20:5}$ acid) and decosahexaenoic acid (DHA, $C_{22:6}$ acid). These two acids change into useful prostaglandin (PG). In recent studies, this PG was demonstrated to prevent adults' diseases such as thrombus and cardiac infarction.

When summing up the physiological action of the EPA and DHA contained in the lipids of fish (the effects of DHA will be explained in

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a later study), one may list the relationships to the following: ① widening the blood vessels, ② inhibiting the agglutination of the blood platelets, ③ lowering the neutral fat in the blood, ④ lowering the blood pressure, ⑤ lowering the VLDL cholesterol and the LDL cholesterol (both harmful cholesterols), ⑥ increasing the HDL cholesterol (beneficial cholesterol) in the blood, ⑦ lowering the viscosity of the blood, ⑧ preventing cerebral infarct, ⑨ stopping cardiac infarct and finally preventing adults' diseases[1)2)].

One may say that at the present time most health food made from EPA and DHA consists of fish oil or fish oil concentrates (in every case redfish).

As long as fish oil is used as material, there are limits to the increase in EPA and DHA contents. However, "EPA + DHA" i.e. the total volume of ω^3 * is closely associated to food effectiveness so that this total amount is an important element when computing the cost price, and an important point in the evaluation of health foods. Products made from EPA + DHA are for reasons of quality preservation sold presently as gelatine capsules. If in the future a technique is developed to stabilize the quality, it would become possible to make and market the substance under numerous forms[1)].

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2. The safety of EPA

As shown above, health foods made from EPA and DHA are commonly used in the form of fish oil and fish oil concentrates. This fish oil

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*The positions of the first double bonds counted from the methyl carbons of the fatty acids are indicatd by ω or by n.

has been ingested for a long time by people as part of their diet (fish diet) and judged through epidemiological examinations to be without danger to the human health[3]. Moreover, with regard to fish oil concentrates, acute and short-term toxicity tests have been performed on rats but no adverse effect could be noticed[1].

However, as the level of unsaturation is high in fish oil, there is a tendency to oxidation because of the oxygen in the air. Through a primary oxidation, the unsaturated fatty acids in fish oil are transformed into hydroperoxides. If these peroxides overlap they generate polymers, and if there is a secondary oxidation, carbonyl compounds and the like will be produced. It is widely known that oxidized fish oil is harmful to the health. So, the Ministry for Health and Welfare set very early the standards of tolerable oxidation for instant noodles and oil cookies. However, with regard to health foods made from fish oil and fish oil concentrates, one must examine the standards of tolerable oxidation and ascertain their safety. Moreover, when using organic solvents in the manufacture process, not even traces of such solvents should remain in the final products. p. 21

EPA and DHA have in their molecules 5 or 6 unsaturated bonds. As the number of double bonds in the molecules increases, oxidation is of course more likely to occur. "EPA + DHA" mixtures are 40 times more likely to oxidize than oleic acid. Therefore, when using EPA - DHA materials as health food, it is important to provide for stabilization against oxidation and to guarantee safety. If we watch the effect of oxygen upon EPA ethyl esters (purity: 66%) we notice that under open conditions, one cannot expect preventing oxidation even by using

antioxidants with 30°C storage. When preserving at the low temperature of 7°C it is possible to prevent fairly well the oxidation even without using antioxidants.

When sealing the substance inside ampoules (30°C) early oxidation progresses because of the sealed-in residual oxygen regardless of whether or not an antioxidant is used. When the oxygen is used up, there is no further oxidation. If the oxygen inside the ampoule is replaced by nitrogen gas, there is no oxidation progress, and we see that eliminating oxygen (substitution by nitrogen gas) and preserving at low temperatures are appropriate. It is thus effective for the quality preservation of fish oil concentrates containing high levels of EPA - DHA to eliminate the oxygen. One proposed solution is to seal the product inside gelatine capsules. However, these capsules are not very resistant to the temperature (oxygen is introduced into the capsules through the medium of water). When the substance is sealed in a container, there is no effect of oxygen or of light rays, long-term preservation is possible and it is said that safety can be guaranteed.[1])

3. Characteristics of the fish lipids

There are numerous types of fish, and the make-up of their components is extremely complex. Often within one same species, there are conspicuous changes in the chemical composition depending on the season and on the age of the fish.

Fish are generally divided widely into redfish and whitefish. We will make a comparative examination of the main components of these two groups. With regard to protein contents, there are no excessive seasonal variations in any of these two groups. The values are

relatively stable at about 20%. In both groups the sum of the fat and water contents is around 80%. However, redfish has more fat and less water. These two components vary greatly according to the seasons. When the fat contents increase, the water contents decrease. These variations are more conspicuous in the redfish which are migratory than in the whitefish which are sedentary. The energy amount of redfish is about double the amount of the same volume of whitefish. This is because there is much lipid and little water in redfish.

As mentioned earlier, the amounts of lipids vary according to the seasons even within the same fish species. This tendency is particularly conspicuous in redfish. Fig. 1 shows the seasonal variations of lipid contents in sardine*[4]. The content rate reaches a peak around mid-January to exceed 17%. This, however, starts to decrease gradually from February and a bottom low of about 1% is reached from late March to April. From around June, the rate increases sharply again until the summer and fall. Such seasonal variations in lipid contents are not limited to sardines but are a trend common to the migratory redfish. It goes without saying that the variations in lipid contents have seasonal lags depending on the species of fish. p. 22

As mentioned already, the lipid contents vary strongly according to the seasons. The water contents also vary concomitantly in the fish meat. As shown for instance in Fig. 2, there is a negative correlation between the lipid and water contents in sardine[5]. That is, when the lipid volume reaches the very high value of 25%, the water content is very low at 60%. When to the contrary the lipids reach the low of 1%, the water content increases to about 80%. Even though the volumes of

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*Sardinops melanosticta Temminck & Schlegel: translator; same herafter.

lipids and of water vary strongly according to the seasons, the volume of protein, however, does not change very much.

There is very much fat in the abdominal meat of tuna. From ancient times this was called "toro" and was appreciated as sashimi and as sushi ingredient. Even the fat contents of this "toro" are fairly high in January-March and October-November. They are lowest around June-July. Like in sardine, the water content is highest when the fat contents are lowest.

The lipid contents vary also according to the part of the body of the fish. Table 1 shows the differences in fat rates by part of the body of cold-weather yellowtail[6]. As the Table shows, there is more fat in the dark muscle than in the ordinary muscle. As for the ordinary muscle, there is more fat in the front than in the rear part, in the abdominal than in the dorsal part, in the outer layer than in the inner layer. As for the internal organs, there was more fat in the pyloric appendage and liver. We thus note considerable differences in fat contents according to the various parts of one same cold-weather yellowtail.

Table 2 shows the differences in total lipid content rates in common horse mackerel according to the seasons and to the parts of the body[7]. When examining the content rates by part of the body, we see that there is more fat in the internal organs than in the meat, that the contents are highest in spring, followed by summertime and that they decrease from the fall to the winter.

The lipid contents in fish show thus general strong variations according to the seasons and parts of the body. There are also variations depending on the age. Even within the same fish, the

distribution is often uneven. For instance, the fat of redfish such as sardine, saury pike, mackerel is stored in the muscles, while most of the fat of cod, squid, shark is stored in the liver. Even within the same species, there is more fat in reared than in naturally free-swimming fish.

When describing the characteristics of fish lipids, one mentions first the high iodine value. The reason is that the lipids of fish are constituted of large volumes of highly unsaturated fatty acids. That is, triglycerides (triacylglycerols) and phospholipids which are the main components of fish muscle fat contain as constitutive fatty acids fairly large amounts of highly unsaturated acids such as EPA and DHA p. 23 absent in cattle meat or poultry. This is why the iodine value is high in fish lipids. Highly unsaturated acids become very easily oxidized, and this is the cause of quality drop in processed marine food as well as of food poisoning. Recently, however, it has become known that EPA and DHA are changed into substances with strong physiological activity inside the body and that they play an important role in the preservation of human health, and they have therefore come into the spotlight.

4. Lipid composition of redfish lipids

The lipids contained in all fish, and not only redfish are according to the differences in functions and distribution divided into storage lipids and tissue lipids, as well as into neutral lipids and polar lipids. The storage lipids consist mainly of triglycerides and accumulate in the subcutaneous tissues, in the muscles, liver and so on, and are used as source of kinetic energy. Meanwhile, the tissue lipids consist mainly of phospholipids, sterols, sterol esters and hydrocarbons.

They are contained in the cells and in the cell walls. They are components indispensable to the maintenance of the life phenomenon, and are not consumed as source of energy. Some species of fish contain also glyceryl ether and wax esters.

We chose typical migratory fish, that is, common horse mackerel, bonito, big-eyed tuna, and show in Table 3 the lipid compositions of the neutral lipid fractions and polar lipid fractions contained in their muscle[8,9]. Generally in the neutral lipid fraction, the triglyceride contents increase as the fish species contains more total lipids. When the contents are low such as in bonito, the triglyceride contents are lower than the [sterol + diglyceride] contents. The neutral lipid fraction consists mainly of stored lipids and the volumes vary sharply depending on the species of fish and the season. Meanwhile, the polar lipid fraction consists mainly of phosphatidyl choline and phosphatidyl ethanolamine. Phosphatidyl serine and sphingomyelin are also contained. As these are tissue lipids, their total volume is about 500-600 mg/100 g, and there is not much difference among the various species of fish.

Table 4 shows a comparison between the lipid composition of yellowtail fish which are widely reared and the compositions in free-swimming fish[10]. All fish were large cold-weather yellowtails. The total lipid contents were 17-18% without differences and most of the components were triglycerides. The volume of the polar lipid fraction was also around 620 mg/100 g, and there were no large differences.

Generally, numerous migratory redfish store their lipids in the subcutaneous tissues and in the muscles. On the other hand, the white sedentary fish store the lipids in the liver and other internal organs, and almost none in the muscles. For instance yellowtail which are typical migratory fish accumulate large amounts of storage lipid

triglycerides in their muscles whereas sedentary fish store almost no triglycerides in their muscles. Nevertheless, there is not much difference between these two groups of fish with regard to the volume of polar lipid contents necessary to sustain life.

5. Fatty acid composition of redfish lipids

Regarding the fatty acid composition of fish lipids, one must study not only the fatty acid composition of the neutral lipid fraction, the phospholipid fraction, the sterol esters fraction, the wax esters fraction, the glyceryl ether fraction, but also the fatty acid composition of the particular lipids constituting these lipid fractions. Yet because of the limitations of our report we will discuss in this study the fatty acid composition of the total lipids only.

We first show in Table 5 the fatty acid composition of the total lipids contained in the muscle of 14 species of redfish together with the same regarding beef's fat and soyabean oil[11)-20)]. The fatty acid compositions shown in the present table represent the composition ratios (weight %) of the various fatty acids vs. the total fatty acids. Consequently, it is not because the composition ratio of fatty acids is high in one species that the amount of fatty acids contents in the meat of this species is necessarily high. There is a large volume of fatty acids in fish meat wherein the composition ratio is high and wherein the total lipid volume is also high.

So when watching the composition ratios of linolic acid ($C_{18:2}$), linolenic acid ($C_{18:3}$) and arachidonic acid said to be fatty acids essential to nutrition, as well as of EPA ($C_{20:5}$) and DHA ($C_{22:6}$) and the like which are considered important for the preservation of health, it is particularly necessary to pay attention to this point.

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As Table 5 shows, in any redfish the fatty acids with a high composition ratio are ($C_{16:0}$, $C_{18:0}$, $C_{18:1}$, $C_{20:5}$, $C_{22:6}$ and the like. The composition ratios of $C_{18:2}$, $C_{18:3}$ and $C_{20:4}$ said to be essential fatty acids are low. There are, however, exceptions. For instance, in the total lipids of saury pike the composition ratio of $C_{20:1}$ is 20% and that of $C_{22:1}$ is also very high at 26.9%.

It is, however, possible that $C_{18:3}$ is admixed in the former and $C_{20:4}$ $\omega 6$ in the latter.

Generally, the fatty acid composition of the total lipids is closely related to the volume of total lipids. In Table 5, the fish species whose total lipid contents are known are few. As indicated in the Table, the total lipid contents rate in bonito is extremely small at 1% or lower. On the other hand, in spite of dependence on seasonal variations, the total lipid contents rate is high in yellowtail. The cotal lipid content rates in common horse mackerel, herring and the like may be said to be high, at 6~8%.

If we exmaine the fatty acid composition of the redfish lipids while considering such total lipid content rates, we see that in bonito which has a low total lipid content rate the composition ratio of polyenoic acids having two or more double bonds is as high as 54%. We also see that in yellowtail, common horse mackerel and herring which have high total lipid contents rates, the above ratios are respectively 19%, 31% and 18%, and remarkably lower than in the former, with the exception of common horse mackerel. The reason why the composition ratios of polyenoic acids in fish species having high total lipid

contents rate are low is that there is little polyenoic acid in the triglycerides constituting the main part of the storage lipids.

If we compare the fatty acid compositions of these redfish lipids to those found in beef lipids, we see that in beef's fat the composition ratio of $C_{18:1}$ amounts to about 50%, and that there are almost no highly unsaturated acids said to be important for nutrition and health preservation. In soyabean oil $C_{18:2}$ amounts to about 50% and $C_{18:1}$ exceeds 30%. Starting with $C_{20:4}$, the highly unsaturated acids are absent.

6. The EPA and DHA of redfish lipids

There are numerous reports on the fatty acid composition of the redfish lipids. Because of writing limitations, we will in this report show in Table 6 the EPA and DHA composition ratios picked up from the fatty acid compositions prepared by the Gas Chromatography Data Subcommittee of the Japan Oil Chemistry Association - Oils and Fats, and Oils and Fats Products Testing Methods Sectional Group[21)-23)].

The numerical values shown in the Table represent the EPA and DHA composition ratios obtained when counting as 100% the total amount of the fatty acids constituting the redfish lipids. As the Table shows, the composition ratios of EPA and DHA are 8-10% and 15-34% respectively for sardine lipids, 8-10% and 11-15% for mackerel* lipids, 5-6% and 7-15% for saury pike lipids. These data indicate that both EPA and DHA are relatively abundant in redfish lipids and that the composition ratio of DHA is higher than that of EPA.

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*Pneumatophorus japonicus (Houttuyn): Translator; same herafter.

Our study group examined and researched for a long time the lipids of the various marine animals, and performed recently a detailed study[24-30] of the lipids of common horse mackerel. From the huge p. 27 amount of data obtained, we extracted only those about EPA and DHA in the total lipids. We present these hereunder.

Fig. 3 shows the seasonal variations of the main fatty acid compositions of the total lipids contained in the meat and total viscera of common horse mackerel[24,30]. Fig. 4 shows by period the variations in main fatty acid compositions of the total lipids contained in the ordinary muscle, dark muscle, skin, liver and viscera (excepting the liver) of common horse mackerel.[26,30]

Meanwhile, Table 7 shows the seasonal variations of EPA and DHA composition ratios (in weight % when considering the total fatty acids as 100%) with regard to the constitutive fatty acids of the total lipids contained in the meat (ordinary muscle and dark muscle) and viscera of common horse mackerel[24,30]. Table 8 shows the period variations[26,30] of the EPA and DHA composition ratios (in weight % when considering the total fatty acids as 100%) of the total lipids contained in the ordinary muscle, dark muscle, skin, liver and viscera (no liver) of common horse mackerel.

From Fig. 3 and Table 7 we see that the fatty acid composition of the total lipid contained in the meat and viscera of common horse mackerel shows for EPA a composition ratio of 6-9.0% and for DHA, a composition ratio of 7.6~17.2%. If we consider Fig. 4 and Table 8, we p. 28 see that in the fatty acid composition of the total lipids contained in the ordinary muscle, dark muscle, skin, liver, viscera (excepting the

liver) of common horse mackerel, the composition ratio of EPA is 7.1~9.5% and that of DHA is 10.3~15.9%.

If we examine in Table 7 the differences according to the different parts of the body, we see that in the fatty acid composition of the total lipids in the meat, the EPA composition ratio is 7.6~9.0% and that of DHA 9.1~17.2%. In the total lipids of the viscera, the EPA composition ratio is 8.0~8.4% and that of DHA is 7.6~11.4%.

If we collate the above, we note with regard to the total lipids in common horse mackerel that ① the composition ratios of both EPA and DHA are high, ② the composition ratio of EPA is lower than that of DHA, ③ the composition ratios of EPA and DHA are higher in the fall and winter than in the spring and summer which is particularly true for DHA. In other words, the EPA composition ratio has few seasonal variations. Yet the DHA composition ratio undergoes strong seasonal variations.

7. The smart method of consuming redfish

(1) EPA and DHA abundant in redfish

Fish is strongly recommended in the countries of Europe and America where many people suffer from heart conditions because of a diet based mainly on meat. There are repeated and widening campaigns promoting "sea food for health".

In the past, fish was the basis of the Japanese diet. Now that there is a gradual change toward a meat diet, one should consider anew fish as food and incorporate fish more effectively into our daily lives.

Large quantities of EPA and DHA said to be good for preventing adults' diseases are contained in the red algae, brown algae and in the

fish, crustaceans as well as marine mammals eating the same. Limiting ourselves to fish, we see from Table 9) that there is more EPA and DHA in redfish such as sardine, mackerel, saury pike than in whitefish such as sea bream or cod. It is therefore more advantageous to prepare and consume common fresh redfish rather than expensive white high-quality fish and to ingest EPA and DHA. There are numerous special Japanese methods of consuming fish such as used with sashimi, roasted fish, boiled fish, fried fish, stewed fish, casserole, soups. Every method is good. Raw consumption such as with sashimi is ideal as the lipids are not oxidized.

(2) Better to choose redfish of the right season

During the 10 days prior to the spawning season, the body of redfish is fat and oily. As the rate of contained fat is high, there is of course much EPA and DHA. Therefore fresh fish taken during this period not only tastes good but a large amount of EPA and DHA is ingested which is extremely beneficial.

For instance, there is much fat in the abdominal meat of tuna. It was called "toro" from old times and appreciated as sashimi or in sushis. There is particularly much oil in the tuna "toro" of January-March, and October-November. Similarily to the "toro" of tuna, one of the fine-tasting winter products is the "cold-weather yellowtail". As the words indicate, it is natural yellowtail taken during the cold season. The reason for the fine taste of cold-weather yellowtail is that the fish meat is full of fat in the winter. Since EPA and DHA are plentiful in the oily fish of this period it is preferable to have redfish of the same period.

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In old cut-open and dried, or simply dried fish, not only do the EPA and DHA oxidize and become degraded, but peroxide lipids and unsaturated aldehydes and the like are formed. Such products should be avoided. When roasted, however, these harmful components are in the end considerably degraded through heat.

(3) Taking simultaneously vegetable oils and vitamin E

The nutritive value of proteins is determined on the basis of the composition ratio of the essential amino acids. It seems, however, that the nutritive value of edible oils and fats also is determined on the basis of the balance in fatty acids.

There is much EPA and DHA in fish oil but the volume of linolenic acid is small and that of linolic acid extremely small. Thus, when eating redfish, one should obtain not only EPA and DHA, but also, via liquid vegetable oils such as soya-bean oil, one should ingest linolic and linolenic acids which are essential fatty acids, and ingest also well balanced fatty acids of all the various types. Rather than using health food made mainly from safflower oil which contains much linolic acid, or fish oil products containing much EPA - DHA, it is more important to use jointly food such as fish and soya beans, and to be careful to consume equally the important fatty acids. When consuming more EPA and DHA through redfish food, one should also not forget to take a little more natural vitamin E than usual to prevent the oxidation of both fatty acids inside the body.

(Note) We wish to thank Dr. Chiaki KOIZUMI, professor at the Tokyo Fisheries University, for his assistance in the preparation of this report.

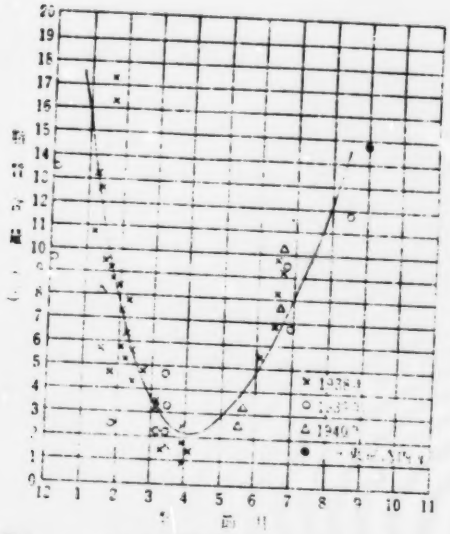

図1 マイワシの脂質含量の季節変化（銚子沖）[4]

Fig. 1 Seasonal variations in the lipid contents of sardine (off Choshi)[4]

a volume of lipid contents (%)
b season (months)
c year
d from Tokyo Bay

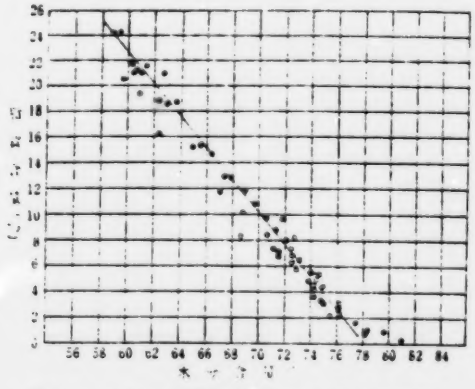

図2 マイワシの脂質含量と水分含量との関係[5]

Fig. 2 Correlation between lipid contents and water contents in sardine[5]

a volume of lipid contents (%)
b volume of water contents (%)

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Table 1 Differences in total lipid content rates (%) of cold-weather yellowtail according to parts of the body[6]

ordinary muscle				dark muscle	viscera	
front dorsal part	outer layer	30.8	front abdominal part outer layer	33.3	front part	31.5	heart	3.3
	inner layer	18.2	inner layer	18.0	median part	43.4	liver	22.4
median dorsal part	outer layer	19.6	median abdominal part outer layer	28.5			pyloric appendage	42.5
	inner layer	12.8	inner layer	16.6	rear part	15.5	spleen	8.7
rear dorsal part	outer layer	16.9	rear abdominal part outer layer	10.0			digestive tract	4.2
	inner layer	8.1	inner layer	10.4			ovary	3.0

Table 2 Differences in total lipid content rates (%) of common horse mackerel according to season and part of body[7]

season	muscle	viscera
spring	12.8	28.8
summer	9.2	25.2
fall	2.9	9.7
winter	3.4	10.8

Table 3 Lipid composition of neutral lipid fraction and polar lipid fraction in fish meat[8][9]

lipid class \ fish species	common horse mackerel	bonito	big-eyed tuna
neutral lipid fraction			
triglycerides	415	54.5	985
sterols + diglycerides	55.8	72.8	101
sterol esters + hydrocarbons	18.7	3.0	tr
free fatty acids	9.9	21.7	44.0
total	499	152	1,130
polar lipid fraction			
phosphatidyl choline*	374	333	311
phosphatidyl ethanolamine	144	96.5	83.8
phosphatidyl serine	69.4	55.7	33.9
sphingomyelin	19.7	59.3	33.9
rhizophosphatidyl choline	7.4	53.9	12.8
unidentified	-	-	-
total	615	599	475

(lipid composition of total lipids)
* includes rhizophosphatidyl ethanolamine

Table 4 Lipid composition of the neutral lipid fraction and of the polar lipid fraction in free-swimming and in reared yellowtail meat[10])

lipid class	natural	reared
neutral lipid fraction		
triglycerides	17.5*2	18.0*2
sterol + diglycerides	10.5	10.8
sterol esters + hydrocarbons	tr	tr
free fatty acids	-	-
total	17.6*2	18.1*2
polar lipid fraction		
phosphatidyl choline*1	403	372
phosphatidyl ethanolamine	137	137
phosphatidyl serine	63.6	55.0
sphingomyelin	25.3	25.9
rhizophosphatidyl choline	7.9	19.6
unidentified	-	-
total	636	610

(lipid composition of total lipids)
*1 includes a small amount of rhizophosphatidyl ethanolamine
*2 g/100 g

Table 5 Fatty acid composition of the total lipids in redfish meat[11)-20)]

表5 赤身魚肉の総脂質の脂肪酸組成[11)-20)]

(重量%)

魚種 脂肪酸*1	マイワシ	ウルメイワシ	マアジ	サンマ	ゴマサバ	カツオ	ビンナガ	ハマチ	メジロ	メバチ	ブリ	コノシロ	カンパチ(1回)	牛肉	大豆
12:0	—	0.2	0.1	—	0.1	—	—	tr	—	—	tr	—	0.3	—	—	—
13:0	—	tr*1	tr	—	0.1	—	—	tr	—	—	tr	—	tr	—	—	—
14:0	7.4	6.0	3.9	4.9	4.4	0.5	2.4	1.9	2.1	6.6	3.3	6.6	8.6	2.9	3.6	—
15:0	0.5	1.6	0.3	0.2	1.2	0.4	0.9	0.9	tr	0.4	1.2	0.4	0.5	0.4	—	—
16:0	25.9	16.6	21.8	10.9	17.4	22.0	11.9	9.5	21.3	18.7	18.5	12.5	18.0	10.6	24.1	13.6
17:0	—	1.4	0.5	0.6	2.9	1.0	1.6	1.0	tr	0.6	2.3	1.3	0.3	1.4	—	—
18:0	3.9	7.0	6.1	2.1	6.4	10.4	3.5	4.3	7.3	4.3	7.0	1.7	4.8	4.1	13.7	2.3
19:0	—	—	0.3	—	—	—	—	—	—	0.1	—	—	—	—	—	—
20:0	—	1.6	0.3	tr	1.2	0.3	tr	1.1	0.4	0.3	tr	0.5	0.3	0.6	—	—
21:0	—	—	tr	—	—	0.4	—	—	—	0.1	—	—	—	—	—	—
22:0	—	tr	tr	tr	0.2	—	0.2	0.5	—	—	tr	—	0.3	—	—	—
23:0	—	—	1.0	—	—	1.2	—	—	—	—	—	—	—	—	—	—
24:0	0.8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
小計	38.5	34.4	34.3	18.7	33.9	36.2	20.5	19.2	31.1	31.1	32.3	23.0	32.9	20.0	41.4	15.9
12:1	—	—	tr	tr	—	—	—	—	—	—	—	—	—	—	—	—
13:1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
14:1	—	—	0.1	—	—	tr	—	—	—	0.1	—	0.4	—	—	1.4	—
15:1	—	—	—	—	—	—	—	—	—	—	—	0.4	—	—	—	—
16:1	4.8	8.4	8.1	4.5	7.1	1.4	11.9	5.1	6.6	7.1	5.4	8.1	13.5	6.7	6.6	—
17:1	—	0.9	—	—	0.9	—	—	0.8	23.8	0.7	1.0	0.3	0.2	0.3	—	—
18:1	11.3	11.0	19.4	5.2	23.9	8.9	15.6	13.1	—	22.1	11.3	25.7	21.4	18.0	50.1	35.0
19:1	—	1.4	tr	—	0.8	—	0.7	1.0	—	0.3	1.1	—	0.4	—	—	—
20:1	4.5	—	2.9	20.0	—	—	0.9	1.0	—	8.6	9.7	11.9	1.5	17.5	—	—
21:1	—	0.4	—	—	0.8	—	0.1	0.6	—	—	0.5	—	tr	—	—	—
22:1	3.5	2.5	tr	26.9*2	4.0	—	1.2	2.0	—	7.9	2.0	11.8	0.5	16.0	—	—
23:1	—	—	—	—	—	—	—	—	—	0.1	—	—	—	—	—	—
24:1	—	2.3	0.3	1.2	tr	—	1.0	1.7	—	0.9	1.4	0.8	0.7	1.4	—	—
小計	24.1	26.9	30.8	57.8	37.5	10.3	31.7	25.9	30.4	18.0	26.4	59.4	38.2	59.9	58.1	35.0

Table 5 - Continued

16:2	0.6	—	1.0	--	—	0.8	--	--	0.8	—	---	—	1.8	0.4	—	—
16:3	—	—	--	—	---	---	—	--	—	—	--	—	--	—	—	—
18:2	1.2	1.1	0.6	1.7	2.1	0.7	2.1	2.1	1.5	1 6	2.2	0.9	1.5	1.6	—	43.5
18:3	0.5	2.4	0.5	0.6	5.4	0 8	1.3	1.7	1.9	0.5	tr	0.3	0 9	--	0.4	5.5
18:4	2.3	2.2	--	3.2	1.2	—	1.6	0.7	—	0.5	0.3	1.1	1.8	—	—	—
20:2	—	tr	1.1	0.5	—	0.3	0.9	—	—	0 2	--	--	—	0.4	—	—
20:3	—	1.5	—	tr	1.1	—	9.3	1.7	—	-	0.8	—	4.3	—	—	—
20:4	1.4	0.8	0.5	0.6	0.5	4.2	0.4	1.1	3.5	t r	0.8	1.1	0.9	0.5	—	—
20:5	11.5	10.7	9.4	6.7	5.8	5.5	0.2	8.5	4.0	5.0	4.1	8.7	12.4	6.8	—	—
21:5	—	—	—	—	-	—	--	—	—	---	---	—	—	—	—	—
22:2	—	—	—	—	—	—	—	—	—	—	—	—	tr	—	—	—
22:3	—	0.5	—	—	tr	—	0.6	—	—	—	—	—	tr	0.3	—	—
22:4	—	tr	0.5	tr	tr	0.1	1.0	2.0	1 6	tr	2.6	—	0.5	0.2	—	—
22:5	2.5	2.0	2.2	1.5	1.6	7.2	0.5	2.4	3.3	2 2	3.6	1.4	1.2	2.0	—	—
22:6	17.4	18.1	14.9	8.0	11.0	38.0	28.7	31 6	21.7	8 6	24.1	4 1	3.3	7.9	—	—
小計	37.4	39.3	31.0	22.8	28.7	53.6	46 6	52.8	38 4	18.6	38.5	17.6	28.6	20.1	0.4	48.7
本同定	—	—	3.9	—	—	—	--	--	1.6	2.3	—	—	—	—	—	—
総脂質含量(%)	2.3	—	6.1	—	—	9.76	—	--	—	—	—	8.3	—	—	—	15.8
文献	11	12	13	12	12	14	12	12	15	16	12	17	12	18	19	20

* 1：分枝脂肪酸および二重結合の位置による異性体は区別していない。

* 2：C20:4ω6を一部混入している可能性がある。

* 3：微量。

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For information only
TRADUCTION NON REVISEE
Information seulement

a species of fish
fatty acid*1
b sardine
c round herring
d common horse mackerel
e saury pike
f mackerel
g bonito
h albacore
i yellowfin tuna
j big-eyed tuna
k yellowtail
l black marlin
m herring
n gizzard shad
o common tuna (toro)
p beef
q soya beans
r subtotal
s unidentified
t total lipids contents (%)
u literature
v *1: The isomers depending on the position of the chain fatty acids and double bonds are not distinguished.
*2: There may be a partial admixture of $C_{20:4\omega6}$
*3: Trace quantity.

Table 6 EPA - DHA content rates in redfish lipids*3 21)-23)

(weight %)

表6 赤身魚脂質のEPA・DHA含有率*3 21)-23)

(重量%)

種　　類	EPA*1	DHA*2	備　　考
マイワシ油[21]	8.2	34.4	2月
マイワシ油	9.8	27.6	
マイワシ油	7.8	15.3	
マサバ油[22]	8.1	10.6	11月
マサバ油	9.5	11.5	11月，肉・皮
マサバ油	8.4	14.6	11月，全魚体
サンマ油[23]	4.9	10.5	大，11月，皮付肉
サンマ油	4.8	7.3	大，11月，[illegible]
サンマ油	5.1	11.4	中，11月，全魚体
サンマ油	6.4	15.4	小，11月，全魚体

*1 EPA：エイコサペンタエン酸
*2 DHA：ドコサヘキサエン酸
*3 含有率：総脂質の全構成脂肪酸を100%としたときの重量比

a type
b remark
c sardine oil
d February
e mackerel oil
f November
g meat-skin
h total fish
i saury pike oil
j large
k meat with skin
l discarded portion
m medium
n small

*1 EPA: eicosapentaenoic acid
*2 DHA: docohexanenoic acid
*3 content rate: weight ratio when counting the total constitutive fatty acids of the total lipids as 100%

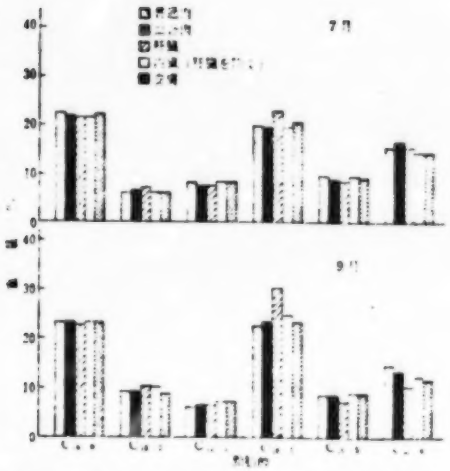

図4　マアジの各種部位に含まれる総脂質の主要脂肪酸組成の時期的変動[26)30)]

Fig. 4　Period-based variations of the main fatty acid composition of the total lipids contained in the various parts of common horse mackerel[26)30)]

a　ordinary muscle
b　dark muscle
c　liver
d　viscera (without liver)
e　skin
f　July
g　September
h　fatty acids

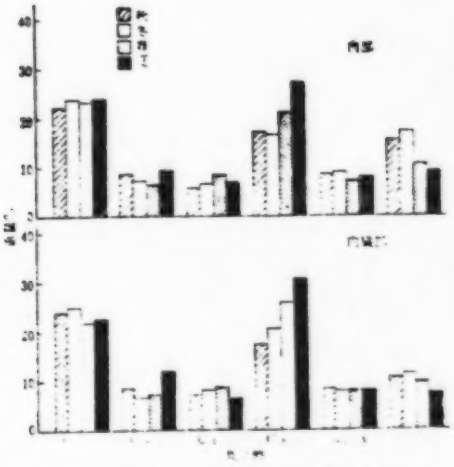

図3　マアジ総脂質の主要脂肪酸組成の季節的変動[24,30]

Fig. 3　Seasonal variations in the main fatty acid compositions of total lipids in common horse mackerel[24,30]

a　fall　　c　spring　　e　meat　　g　fatty acids
b　winter　　d　summer　　f　viscera

Table 7　Seasonal variations of the EPA-DHA content rates* in the total lipids of common horse mackerel[24,30]

表7　マアジ総脂質に含まれるEPA・DHA含有率*の季節的変動[24,30]

(重量%)

漁獲季節	内臓		肉	
	EPA	DHA	EPA	DHA
春	7.6	10.6	8.0	9.7
夏	8.1	9.1	8.0	7.6
秋	8.5	15.8	8.4	10.8
冬	9.0	17.2	8.2	11.4

* 含有率：全構成脂肪酸を100%とした場合の重量比

a　(weight %)　　c　meat　　e　spring　　g　fall
b　season of catch　　d　viscera　　f　summer　　h　winter

i　*content rate:　weight ratio when counting the total constitutive fatty acids as 100%

Table 8 Variations of EPA-DHA content rates*1 in the total lipids of the various parts of the body of common horse mackerel[26)30)]

表8 マアジの各種部位の総脂質に含まれるEPA・DHA含有率*1の変動[26)30)]

(重量%)

部位	7月漁獲		9月漁獲	
	EPA	DHA	EPA	DHA
普通肉	9.4	14.9	8.3	14.3
血合肉	8.7	15.6	8.4	13.7
皮	9.1	14.0	8.5	11.5
肝臓	8.4	25.1	7.1	10.3
内臓*2	9.5	14.2	8.6	11.8

*1 含有率：全脂肪酸物質を100%とした場合の重量比
*2 内臓：肝臓を除く

a weight %
b part
c July catch
d September catch
e ordinary muscle
f dark muscle
g skin
h liver
i viscera*2

j *1 content rate: weight ratio when counting the total constitutive fatty acids as 100%
*2 viscera: without liver

Table 9 Total lipids and EPA-DHA contents[1)] in the main fish species

表9 主な魚類に含まれる総脂質量とEPA・DHA含有量[1)]

魚種	可食部100g当り		
	総脂質量	EPA	DHA
マサバ	16.5g	0.89g	0.7g
サンマ	16.2	0.87	0.7
マイワシ(春)	13.8	1.01	0.37
マアジ(春)	6.9	0.28	0.29
カツオ	2.0	0.09	0.36
カレイ	2.2	0.05	0.02
クロダイ	1.7	0.04	0.17
タラ	0.4	0.05	0.05
スズキ	2.5	0.02	0

a fish species
b per 100 g of edible part
c total lipids
d common mackerel
e saury pike
f sardine (spring)
g common horse mackerel (spring)
h bonito
i flatfish
j black sea bream
k cod
l sea bass

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*Translator's note: Probable reading only; not certain.

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